National Aeronautics and
Space Administration
Office of Biological and Physical Research

Highlighting the Human Experience in Space

NASA Studies Colloids in Space

Why It Is Important

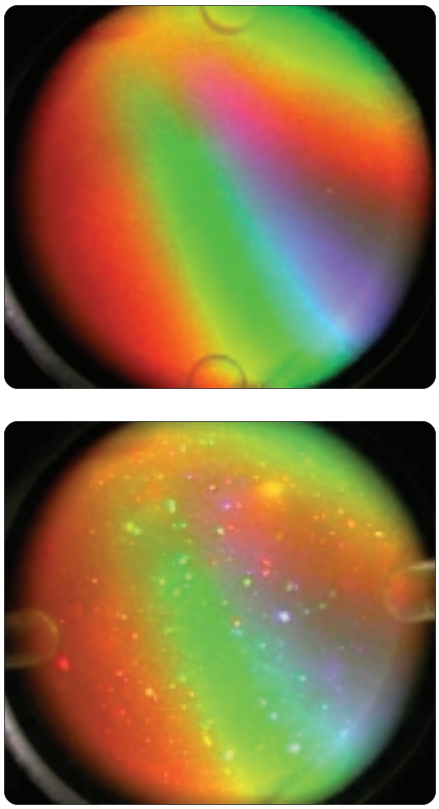
A colloid is a system of fine particles suspended in a fluid. Scientists hope to better understand how colloidal structures grow and behave. The long-term goal is to learn how to control their growth to create new materials via self-assembly—a process called colloid engineering. These materials may result in improved speed and reduced size of computers and telecommunication networks.

What NASA Is Doing

The Physics of Colloids in Space (PCS) is an EXPRESS Rack-based microgravity science experiment currently being performed on the International Space Station until August 2002. PCS is being remotely operated from the NASA Glenn Research Center's Telescience Support Center and at a remote site at Harvard University. PCS is gathering data on the basic physical properties of colloids by concurrently studying three different types of colloids consisting of tiny manmade particles of either polymethyl methacrylate (PMMA), silica, or polystyrene. The samples being studied include binary colloidal crystal alloys (dispersions of two different-sized particles), colloid-polymer mixtures (particles suspended in a polymer fluid), and fractal aggregates (colloidal gels). The objective is to understand how colloidal structures grow, the rates at which they grow, and the structures that they form. This information is useful to gain insight into the basic nature of liquid-to-solid phase transitions, to better understand how colloidal constituent properties affect the properties of the bulk colloidal suspension, and to begin to probe the unique light-scattering properties of nano-engineered binary colloidal alloys.

What the Benefits Are

The potential payoffs of PCS are advances in colloid engineering which can be used to produce photonic band gap crystals that affect the properties of light passing through them. Light can be used to store, transfer, and process information in a way that is more efficient and faster than electric currents because using light avoids overheating in the circuitry and eliminates the charge/discharge time that occurs in electric circuits. Such photonic crystals may find uses as optical switches, filters, and lasers for advanced telecommunication networks and displays. Other potential uses include improvements in the properties of drug delivery products (e.g., encapsulation of drugs), food (shelf life), cosmetics (optical properties), and paints.



The samples above are lexan plastic spheres mixed in an organic (alcohol-like) solvent. The different regions of the sample cell scatter different wavelengths of illumination, thus producing the colors. In space, the crystals are high-quality single crystals that are nearly the same size and uniformly dispersed since there is no sedimentation. Because sedimentation occurs in 1 g (Earth), the concentration of particles becomes significant. These crystallites join together to produce comparatively large, poorly formed poly-crystals.

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NASA contacts: Dr. Francis Chiaramonte 202-358-0693, Michael Doherty 216-433-6641, Dr. Subramanian Sankaran 216-433-9335
Related Web sites: *http://microgravity.grc.nasa.gov/6712/pcs.htm, http://spaceresearch.nasa.gov/*

New Evidence on the Role of Gravity in Fertilization

Why It Is Important

NASA researchers have uncovered evidence that gravity, or the lack thereof, may play an important role in the development and evolution of life. The study suggests that fertilization is gravity-sensitive and works differently in the near-weightless environment of space from how it works here on Earth.

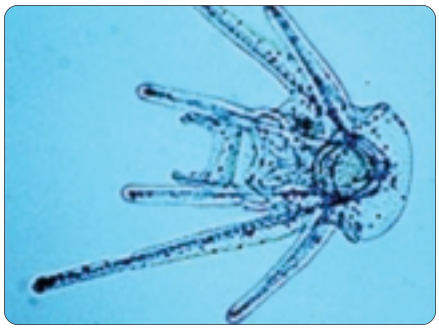
What NASA Is Doing

Using sperm from tiny sea urchins, the research team conducted both ground- and space-based experiments to examine the impact gravity has on the reproduction process. The research team used semen and eggs from the tiny marine creatures to study motility and interaction during periods of increased gravity and near-weightlessness. Studies conducted during Space Shuttle missions showed changes in cell proteins that stimulated and increased the activity of the sperm cells. However, by spinning the cells in a slow-speed centrifuge to increase gravity, sperm activity was decreased, suggesting that fertilization may be inhibited by exposure to increased levels of gravity.

What the Benefits Are

According to a paper authored by Dr. Joseph Tash, a NASA researcher and professor at the University of Kansas Medical Center in Kansas City, scientists found that gravitational changes may influence a species' ability to reproduce. His team's findings were published in a recent issue of Biology of Reproduction. Other team members included Shane Kim and William Kinsey from the University of Kansas Medical Center, as well as Marianne Schuber and Dieter Seibt from the German Aerospace Center, Koln, Germany. "This research shows that fertilization is altered in a microgravity environment," said Tash. "Such alterations have implications for reproduction of plant and animal food and for long-term space habitation by humans."

The experiments were conducted under a grant from NASA's Office of Biological and Physical Research in Washington, DC. The research program provides investigators with the opportunity to use microgravity or low-gravity environments to investigate the role that this fundamental physical force and other space flight factors have on biological and ecological systems.



A NASA Ames Research Center image showing a sea urchin larva being studied for the impact of gravity on fertilization.

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NASA contact: Dr. David Liskowsky 202-358-1963
Related Web site: *http://spaceresearch.nasa.gov/*

NASA Seeks New Ways to Fight Fire

Why It Is Important

The use of water mist for fire suppression is currently receiving increased attention as a replacement technology for halogen-based chemical agents such as Halon 1301 (CF_3Br). The manufacture of halogen-based chemical agents has been banned by the Montreal Protocol because of their high ozone-depleting potential. All fire protection system extinguishing agents can affect the environment; however, fire protection halons are of primary concern. Like refrigerants and propellants, fire protection halons are fluorocarbons. A fire protection halon is the most damaging halon to the ozone. As a result, the fire protection community has had to move quickly to work out ways of acceptably controlling loss potential while minimizing the use of this previously well-accepted extinguishing agent.

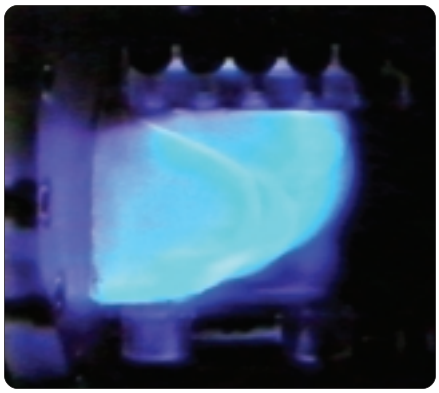
What NASA Is Doing

The NASA-sponsored Center for Commercial Application of Combustion in Space (CCACS), a Commercial Space Center, in conjunction with Glenn Research Center and industry partners Environmental Engineering Concepts and Arizona Mist, is investigating the properties of mist fire suppression in microgravity. These experiments consist of varying water droplet sizes and water mist concentrations applied to flame fronts of different propane/air mixtures. Observations from these tests will provide valuable information on the changes of flame speed in the presence of water mist. The Water Mist experiment will be conducted on the STS-107 Space Shuttle research mission.

What the Benefits Are

With most of the major and most effective chemical extinguishing agents targeted for limited use, there exists an urgent need for new environmentally acceptable fire suppression systems throughout the public and private sectors. The lack of availability of halon fire suppressants has sparked worldwide efforts in developing alternative fire suppression agents and delivery systems. The commercial potential includes engineered fire suppression systems that are safe, effective, and environmentally benign. Additionally, the methodology developed will then be extended to other chemical fire suppression agents with the development of unique standard testing apparatus for the Shuttle and the ISS, wherein new agents can be tested in microgravity.

The next-generation fire suppression is expected to become an increasingly large part of the $2-billion-a-year fire suppression industry.



The Water Mist commercial research program is focused on developing water mist as a replacement for bromine-based chemical fire suppression agents (halons). By conducting the experiments in microgravity, interference from convection currents is minimized and fundamental knowledge can be gained. The immediate objective of the project is to study the effect of a fine water mist on a laminar propagating flame. The effects of droplet size and concentration on the speed of the flame front is used as a measure of the effectiveness of fire suppression in this highly controlled experimental environment. Shown here is a flame front propagating through the Water Mist flame tube during 1-g (Earth) testing at NASA's Glenn Research Center.

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NASA contact: John Emond 202-358-1686
Related Web sites: *http://spaceresearch.nasa.gov, http://commercial.nasa.gov, http://cscsourcebook.nasa.gov, http://spd.nasa.gov*

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Highlighting the Human Experience in Space

NASA Supports Research to Treat Osteoporosis

Why It Is Important

According to the National Osteoporosis Foundation (*http://www.nof.org*), osteoporosis is diagnosed in 10 million Americans, and another 18 million are at risk. Approximately 80 percent of these cases are in women. Osteoporosis results in over 1.5 million fractures every year, with more than 25,000 deaths due to complications of these fractures. It is estimated that osteoporosis cost society approximately $14 billion in 1995. On a worldwide basis, these numbers are much larger and growing, as a result of an aging world population. In addition to the obvious financial costs, osteoporosis also causes significant deterioration in lifestyle and loss of productivity in society at large.

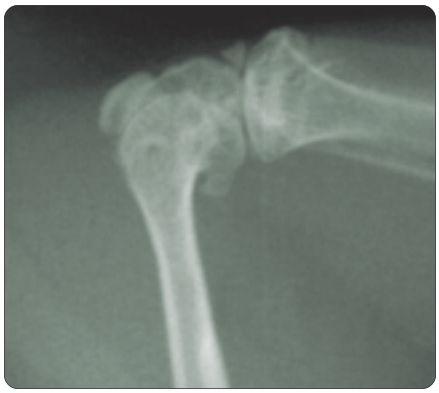
What NASA Is Doing

Osteoprotegerin (OPG) is a recently discovered, naturally circulating protein that increases bone density by inhibiting the dissolving and reabsorbing by the body of bone tissue (resorption). Amgen, Inc., is developing OPG to treat osteoporosis and metastatic bone cancer. Amgen is currently in FDA Phase I clinical trials for both diseases. BioServe Space Technologies, a NASA Commercial Space Center, and Amgen have been working together for four years to examine the ability of OPG to treat disuse-related osteoporosis. These studies, along with other preclinical models used by Amgen, indicate that OPG may be a safer and more efficacious treatment for inhibiting bone resorption than is currently available. Amgen sponsored an experiment on NASA's UF-1 mission extending the terrestrial disuse studies to a space flight examination of OPG in mice. Space flight offers a unique environment where, in the absence of normal signals from gravitational loading, the skeletal system loses mass and becomes weaker. It is expected that space flight will induce a more systemically complete skeletal unloading, and thus be a better model than other disuse models.

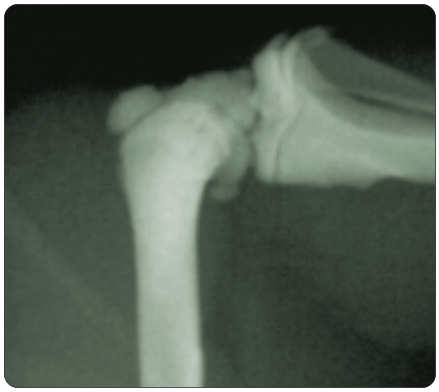
What the Benefits Are

OPG is likely to be a significant advancement in the treatment of osteoporosis because it appears to be more effective than the treatments currently available. Because it is a naturally occurring protein, it is predicted that safety will be increased and the number of side effects reduced. As a treatment, OPG may be required much less frequently, which could represent a strong advantage over currently available therapies. This research may also aid astronaut crews who live in space for extended-duration periods by countering the effects of microgravity on resorption.

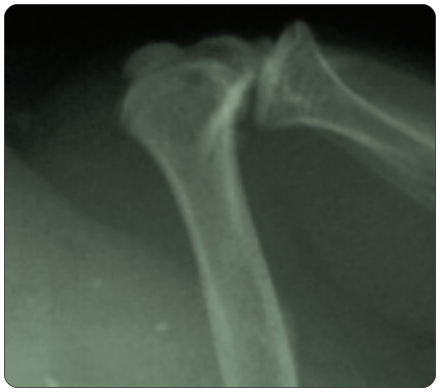
OPG is a physiological regulator of bone density.



Normal OPG



Extra OPG (transgenic)



Lack of OPG (knockout)

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NASA contact: John Emond 202-358-1686
Related Web sites: *http://spaceresearch.nasa.gov, http://commercial.nasa.gov, http://cscsourcebook.nasa.gov, http://spd.nasa.gov*

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NASA Conducts Boiling Experiments in Space

Why Is It Important

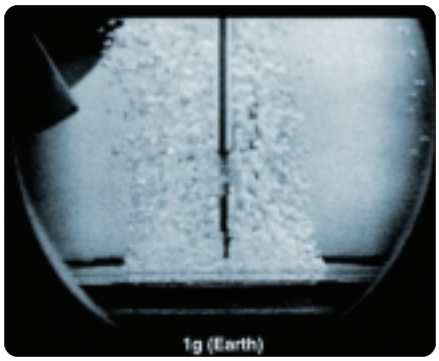
Boiling is an effective method of transferring energy and can lead to decreases in current space-based heat exchanger size, resulting in weight and cost savings. Also, boiling experiments in space can lead to a better understanding of boiling on Earth because the process is simplified in space with the near-absence of buoyancy-induced convection.

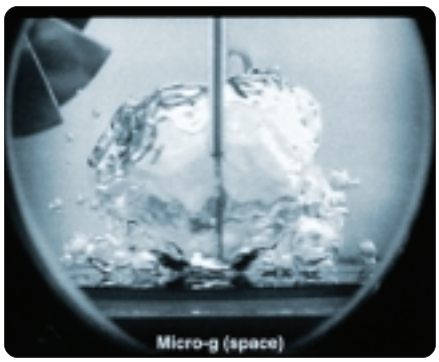
What NASA Is Doing

NASA has conducted boiling experiments on the Space Shuttle and is planning more advanced experiments (the Microheater Array Boiling Experiment) on the International Space Station (ISS). The highly successful Pool Boiling Experiment (PBE) was conducted on five Space Shuttle missions. The objective was to improve the understanding of the fundamental mechanisms that constitute nucleate pool boiling. Results from space showed the following "first findings": 1) steady state pool boiling was possible in microgravity under certain conditions; 2) the heat transfer was enhanced as a result of small bubbles' migrating toward a larger one because of temperature-dependent surface tension effects; 3) a pool boiling curve was constructed indicating an enhancement in the nucleate boiling regime, which increases with subcooling, as compared to boiling on Earth; and 4) high heater surface temperatures at the onset of boiling resulted in the explosive growth of vapor bubbles, also under certain conditions. PBE also demonstrated that large bubbles can be sustained over the heater for long periods in microgravity, a distinct advantage in observing the bubble's edge as compared to using the smaller bubbles produced on Earth (see photo). Building on the knowledge gained from these prior Shuttle experiments, the ISS experiment will determine the local boiling heat transfer mechanisms in microgravity and microscopically examine the boiling process at the bubble's edge. It is postulated that most of the energy is transferred and vapor generation occurs through this region.

What the Benefits Are

Understanding how liquids boil in microgravity is necessary for designing more efficient space power plants (e.g., boilers and heat exchangers), life-support systems, and cooling systems for electronic components on spacecraft. Boiling uses the latent heat of phase change, which can remove energy more efficiently than sensible heat. This leads to higher power-to-weight-ratio energy systems. The knowledge gained from these experiments may also lead to improved performance of terrestrial power plants.





In 1-g (Earth gravity) boiling, the action of buoyancy allows the bubbles to overcome surface tension forces. The bubbles rise upward away from the surface. In micro-g (space) boiling, the buoyancy force is very weak. Consequently, the bubbles often remain attached to the heater due to surface tension and grow with continued heat input.

To view an 18-second Quicktime movie, please go to the Pool Boiling Experiment Web site listed below. Also, you may obtain a 67-minute **video** of the Pool Boiling Experiment microgravity boiling results by contacting the NASA Glenn Research Center at 216-433-6159 and specifying tape number 396.

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NASA contact: Dr. Francis Chiaramonte 202-358-0693, John McQuillen 216-433-2876
Related Web sites: *http://microgravity.grc.nasa.gov/expr/pbeinfo.htm, http://SpaceResearch.nasa.gov/*

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Highlighting the Human Experience in Space

NASA Research Shakes Up Bones

Why It Is Important

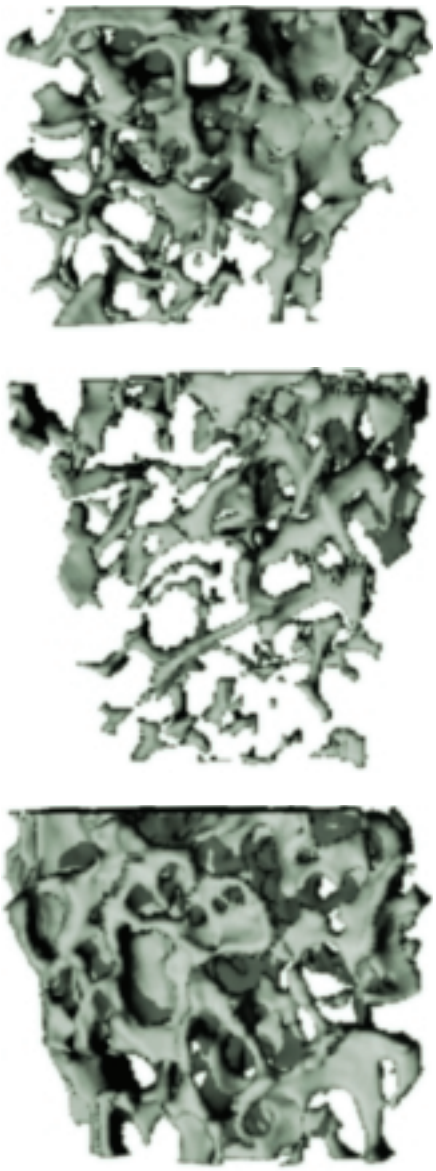
The bones that make up a human skeleton have a remarkable ability to adapt to the daily mechanical demands that are placed upon them. People who exercise more have greater skeletal mass compared to people who do not exercise. Because our bones are constantly required to support our bodies against the pull of Earth's gravity, it is not too surprising that astronauts who spend prolonged periods of time in microgravity lose bone mass. This loss of bone mass not only puts the astronauts at a greater risk of developing kidney stones from the excess calcium that is mobilized from the unloaded bone, but also (and perhaps more critical), it decreases the quality and quantity of bone comprising the skeleton, which makes the skeleton more susceptible to fractures when the it is suddenly reexposed to the pull of gravity on Earth.

What NASA Is Doing

NASA-supported research conducted by Dr. Clinton Rubin at the State University of New York in Stony Brook, New York, is investigating the effectiveness of barely perceptible vibrations that are continually present during routine activities, such as standing, in maintaining or increasing the quality and quantity of bone in the skeleton. Dr. Rubin has been vibrating the skeletons of a variety of lower vertebrates, and also humans, to determine what influence the intervention has on bone. Preliminary results demonstrate that this extremely low-level mechanical stimulus, applied for very short durations each day, is capable of improving both the quality and quantity of bone in the skeleton.

What the Benefits Are

If the low-level strains from the vibration of the skeleton are indeed therapeutic for bone even during the skeletal unloading that occurs during prolonged space flight, it could serve as the basis for preserving the skeletons of the astronauts and combat skeletal disorders such as osteoporosis here on Earth.



The top picture shows normal bone; the center picture shows the bone loss associated with unloading (white spaces). The bottom picture shows unloaded bone treated with the vibration "therapy."

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NASA contact: Bruce Hather 202-358-1796
Related Web site: *http://spaceresearch.nasa.gov/*

Space Radiation Protection

Why It Is Important

Astronauts in space need protection from the exposure to space radiation that results from passage through interstellar material. The consequences of excessive exposure to space radiation are likely to include an increased probability of developing cancer and other biological damage. The research NASA sponsors to deal with this problem will also be useful for medical treatments on Earth, in which patients are subjected to radiation for cancer.

What NASA Is Doing

The most cost-effective way of investigating the danger of space radiation is at ground-based laboratories capable of investigating the nuclei of hydrogen. However, nuclei of all other elements are also present in space in smaller amounts. Although the proportion of heavier nuclei is small, nuclei of all elements up to iron make a much larger contribution to radiation risk in space than the relatively more numerous protons. Simulation of the proton component can be achieved at proton accelerators, of which the Loma Linda University Therapy Proton Synchrotron is the only one equipped to handle the sophisticated biological research required.

Nuclei of atoms heavier than hydrogen are accelerated into high-energy beams at the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory in Long Island, New York, and in the Booster Synchrotron, used as an injector in the accelerator chain leading to the AGS. The AGS only covers the high-energy part of the full-energy range. Currently, an irradiation facility is under construction to take advantage of the Booster Synchrotron. This Booster Applications Facility will provide access for biological and physical research using the full range of particle energies available at Brookhaven.

What the Benefits Are

NASA ground-based studies have shown that lightweight materials such as polyethylene have superior shielding properties against space radiation. As predicted, when panels of this material were added to shield sleeping areas in the International Space Station, a reduction in radiation exposure of approximately 30 percent was observed. The research, performed in cooperation with other Federal agencies and our international partners, will also contribute to breakthroughs in radiation biology and to an improved understanding of cancer biology on Earth.

View of BAF construction as of August 2001.

Polyethylene panels being installed to provide additional shielding in crew sleeping quarters of ISS.

NP-2002-02-281-HQ

NASA contact: Dr. Walter Schimmerling 202-358-2205
Related Web site: *http://spaceresearch.nasa.gov/*